Journal of Forensic and Legal Medicine 20 (2013) 548–550

Contents lists available at SciVerse ScienceDirect

Journal of Forensic and Legal Medicine

journal homepage: www.elsevier.com/locate/jflm

Case report

Temporal evolution in peritoneal hemorrhage as depicted by postmortem CT

Daisuke Miyamori MD [a], Noboru Ishikawa DDS, PhD [a], Yoshihisa Akasaka [a,b], Kei Yamada MD, PhD [b], Hiroshi Ikegaya MD, PhD [a,*]

[a] Department of Forensic Medicine, Graduate School of Medical Science, Kyoto Prefectural University of Medicine, 465 Kajiicho, Kamigyo, Kyoto 602-8566, Japan
[b] Department of Radioligy, Graduate School of Medical Science, Kyoto Prefectural University of Medicine, 465 Kajiicho, Kamigyo, Kyoto 602-8566, Japan

A R T I C L E I N F O

Article history:
Received 26 July 2012
Received in revised form
4 October 2012
Accepted 3 March 2013
Available online 26 March 2013

Keywords:
Postmortem CT
Abdominal injury
Peritoneal hemorrhage
Postmortem change

A B S T R A C T

Background: Computed Tomography (CT) is now utilized as an effective tool for postmortem diagnoses. However, reports on the temporal evolution in imaging findings of these postmortem CT is limited.
Case presentation: One night, a 66 year old male following drinking at a bar on his way home slept in the road. He was ran over by a taxi at 01:28 and immediately transferred to a nearby hospital. During his transfer to the hospital, he lost consciousness and fell into a state of cardiopulmonary arrest, and died despite resuscitation attempts. CT images were taken at 02:30. Following this, CT images were re-taken 54 h after death, just prior to a medicolegal autopsy.
Result & discussion: Small amount of intra-abdominal hemorrhage was found during the initial CT examination. However, the extent of intra-abdominal bleeding observed during the second CT examination performed 54 h later had substantially increased. During the autopsy, the amount of intra-abdominal hemorrhage was 1700 mL. Injury to the mesentery, liver and pancreas was also observed. Additional major injuries discovered during the autopsy were, skin abrasions and lacerations of the scalp, subarachnoid hemorrhage, fractures of the ribs, right humerus, and pelvic bones. The deceased postmortem blood alcohol level was 2.4 mg/mL. The cause of death was determined as exanguination due to systemic injury. The mechanism of the postmortem increase in the intra-abdominal hemorrhage remained unknown. However, the amount of bleeding found during autopsies may not be the same as that at the time of death. As a result, the criteria for the diagnosis of the cause of death in autopsies should be carefully reconsidered. In addition, accompanying CT imaging at the time of death and possible postmortem changes should be carefully considered in postmortem CT imaging, so that there will not be incorrect assignment of the causes of death.
© 2013 Elsevier Ltd and Faculty of Forensic and Legal Medicine. All rights reserved.

1. Introduction

Recently, postmortem imaging through computed tomography (CT) is widely used in determining the cause of death in unnatural reported deaths. This is particularly applicable in Japan with a third of the world's CT machines, making this tool a ubiquitous one. Additionally, there is a strong trend of CT imaging replacing autopsies as the postmortem diagnosis method. However, clinical radiologists and not forensic radiologists conduct most postmortem CT imaging, and postmortem changes are not discussed when determining the cause of death. In this report, CT images taken at the time of death and those re-taken 54 h later are compared and differences between the two sets of images are discussed in addition to the autopsy findings.

2. Case presentation

A 66-year old male with no history of disease was run over by a motor vehicle near his home. One night, he started drinking at 20:00 at a bar near his house and left for home around midnight. It is believed that owing to his drunken state he slept in the middle of the road. He was then ran over by a taxi at 01:28 and was transferred to hospital immediately. When he arrived at the hospital, he was completely unconscious and was also in a state of cardiopulmonary arrest. He died despite resuscitation attempts. CT images were taken at 02:30. Liver and pancreas injury, lower back

* Corresponding author.
E-mail addresses: ikegaya-tky@umin.ac.jp, ikegaya@koto.kpu-m.ac.jp (H. Ikegaya).

1752-928X/$ – see front matter © 2013 Elsevier Ltd and Faculty of Forensic and Legal Medicine. All rights reserved.
http://dx.doi.org/10.1016/j.jflm.2013.03.010

contusion, pelvic bone fracture, vertebral bone fracture, laceration wounds of the left temporal region, laceration of the left auricle, right shoulder contusion, and intra-abdominal hemorrhage were clinically diagnosed at the hospital. As his death was caused by a traffic accident, a medicolegal autopsy was performed two days after the incident. CT images were re-taken 54 h after death, just before the medicolegal autopsy.

2.1. Radiologic findings

2.1.1. Abdominal CT imaging taken immediately after death (Fig. 1a)

The left renal calculus. Consolidation of the pancreas head. Calcification of the right intra-abdominal hemorrhage.

In these series of CT imaging, the volume of the intra-abdominal hemorrhage were estimated utilizing by Osirix® v.3.7.1. This software estimates the volume of intra-abdominal hemorrhage following manual intra-abdominal hemorrhage boundary definition on each individual CT image.[1] Then all region of interest was grouped and the volume was computed. Intra-abdominal hemorrhage was estimated as 600 mL (Fig. 2).

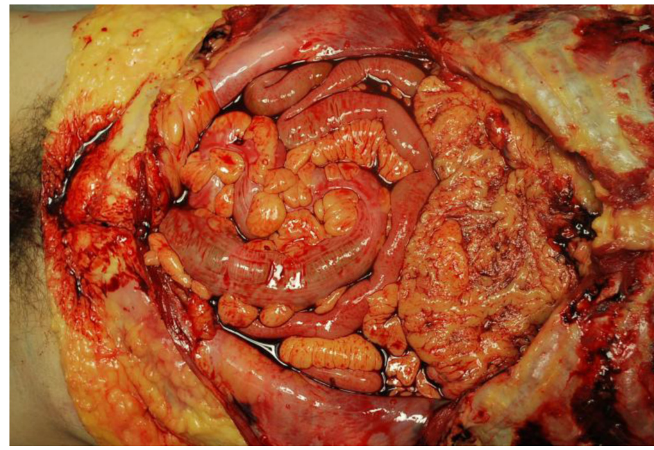

Fig. 2. The photo of the intra abdominal hemorrhage taken during the medicolegal autopsy. During the autopsy, 1700 mL of intra-abdominal hemorrhage was observed. In addition, mesentery, liver and pancreas injuries were observed. Further injuries were found during the autopsy including, multiple rib fractures, skin abrasions and lacerations of the head, subarachnoid hemorrhage, pelvic fracture, and fracture of the right humerus.

2.1.2. CT imaging 54 h after death (Fig. 1b)

The left renal calculus. Decreased consolidation of the pancreas head. Calcification of the abdominal aorta. Right and left intra-abdominal hemorrhage. Collapse of the abdominal aorta. The volume of intra-abdominal hemorrhage was estimated as 1620 mL utilizing by Osirix®.

2.1.3. Autopsy findings

During the autopsy, 1700 mL of intra-abdominal hemorrhaging was observed. In addition, mesentery, liver and pancreas injuries were observed. Further injuries were found during the autopsy including, multiple rib fractures, skin abrasions and lacerations of the head, subarachnoid hemorrhage, pelvic fracture, and fracture of the right humerus. The deceased's postmortem blood alcohol level was 2.4 mg/mL, no drugs were detected in his blood. A hemorrhagic shock due to the systemic injuries was determined as the cause of death.

2.1.4. Findings possible through the CT imaging and not through the autopsy

Multiple small cerebral infarctions, cervical spondylosis, a few mediastinal lymph nodes, a few bullae at the lung apex and the left renal calculus are visible.

2.1.5. Findings possible through the autopsy and not the through CT imaging

Head laceration and abrasions, subcutaneous bleeding in extremities, small amounts of traumatic SAH, hepatic injury and anterior longitudinal ligament injury between Th12 and L1 are visible.

3. Results and discussion

Small amounts of intra-abdominal hemorrhaging were visible in immediately taken CT images. From these primary images, the cause of death could be determined as hemorrhagic shock due to the systemic injuries. However, the extent of intra-abdominal bleeding observed through CT images 54 h later had substantially increased. Therefore, exsanguination could be determined as the cause of death from the later images.

In this case, the estimated volume of intra-abdominal hemorrhage is similar to that of the autopsy findings. Additionally, while it is always preferential to conduct autopsies on such cases, it may be concluded that in cases where autopsies cannot be performed that intra-abdominal hemorrhage estimation through Osirix® is viable. However, the manual nature by which intra-abdominal hemorrhage boundary definition is conducted is a limitation.

The amount of intra-abdominal bleeding found during autopsies may differ from that found at the time of death. In other words, although a victim may have died from blood loss, CT imaging taken immediately after death may not provide evidence of sufficient bleeding to determine exsanguination as the direct cause of death. As a result, the criteria for the diagnosis of deaths in autopsies

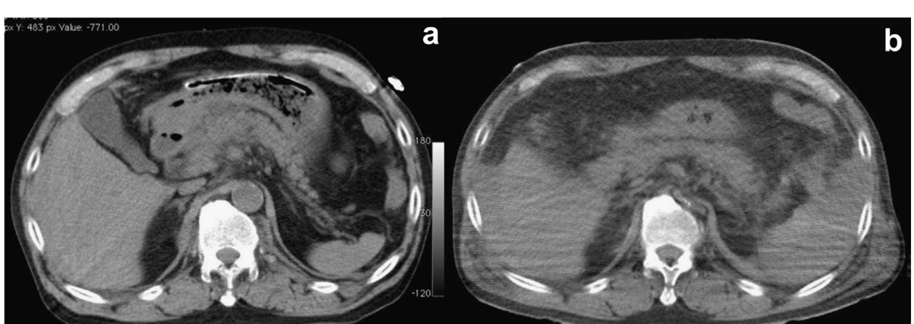

Fig. 1. Comparison of the CT images at different postmortem time. (a) Shows the abdominal CT imaging taken immediately after death. The left renal calculus. Consolidation of the pancreas head. Calcification of the abdominal aorta. Right intra-abdominal hemorrhage. (b) Shows the CT imaging 54 h after death. The left renal calculus. Decreased consolidation of the pancreas head. Calcification of the abdominal aorta. Right and left intra-abdominal hemorrhage. Collapse of the abdominal aorta. The extent of intra-abdominal bleeding observed through CT images 54 h later was greatly increased.

should be carefully reconsidered. Alternatively, the commonly believed extent of bleeding necessary to cause death by exsanguination may need to be revised.

The mechanism of the postmortem intra-abdominal hemorrhage has previously not been reported. However, Shiotani et al. have reported postmortem changes captured through CT imaging.[2] They reported the exudation of the lungs overtime utilizing CT imaging. They report that this was predominantly caused by gross intravenous infusion during the resuscitation and increased vascular permeability during the postmortem period.

However, in the present case, resuscitation was only performed by mechanical ventilation and closed-chest cardiac massage. Additionally, the amount of IV infusion was minimum. Therefore, the increased intra-abdominal hemorrhage cannot be considered as a secondary effect of infusion. The bleeding from the injured vessels in the abdomen probably continued after death because the abdomen lacks surrounding bones that support the intra-abdominal soft tissue. Then the soft tissue under gravity applies pressure upon the abdominal vessels and causes postmortem intra-abdominal hemorrhage.

Yamazaki et al. reported that ascites captured through CT imaging should be a useful indicator of blunt abdominal trauma.[3] Additionally, the postmortem virtual estimation of free abdominal blood volume has been investigated.[4] However, this case suggests that in some cases postmortem intra-abdominal bleeding may increase over time.

Postmortem change in the heart captured through CT imaging has also been reported.[5] It is recommended in this report that the cause of death should not be exclusively determined through CT imaging, and where this is the case, CT images are taken over a period of time. CT imaging has been reported as a useful tool for determining the cause of death.[6,7] However, it is worthwhile remembering that the cause of death should not be determined through CT imaging alone, but CT imaging may be used to support evidence established through medicolegal autopsies.

Ethical approval

None.

Funding

None.

Conflict of interest

None.

References

1. Rosset Antoine, Spadola Luca, Ratib Osman. OsiriX: an open-source software for navigating in multidimensional DICOM images. *J Digital Imaging* 2004 Sep;**17**(3):205–16.
2. Shiotani S, Kobayashi T, Hayakawa H, Kikuchi K, Kohno M. Postmortem pulmonary edema: a comparison between immediate and delayed postmortem computed tomography. *Leg Med (Tokyo)* 2011 May;**13**(3):151–5.
3. Yamazaki K, Shiotani S, Ohashi N, Doi M, Kikuchi K, Nagata C, et al. Comparison between computed tomography (CT) and autopsy findings in cases of abdominal injury and disease. *Forensic Sci Int* 2006 Oct 16;**162**(1–3):163–6.
4. Ampanozi G, Hatch GM, Ruder TD, Flach PM, Germerott T, Thali MJ, et al. Postmortem virtual estimation of free abdominal blood volume. *Eur J Radiol* 2012 Sep;**81**(9):2133–6.
5. Shiotani S, Kohno M, Ohashi N, Yamazaki K, Nakayama H, Watanabe K, et al. Dilatation of the heart on postmortem computed tomography (PMCT): comparison with live CT. *Radiat Med* 2003 Jan–Feb;**21**(1):29–35.
6. Donchin Y, Rivkind AI, Bar-Ziv J, Hiss J, Almog J, Drescher M. Utility of postmortem computed tomography in trauma victims. *J Trauma* 1994 Oct;**37**(4):552–5 [discussion 555–6].
7. Leth PM. Computerized tomography used as a routine procedure at postmortem investigations. *Am J Forensic Med Pathol* 2009 Sep;**30**(3):219–21.